

Frequency of MB2 Canals in Maxillary First Permanent Molars

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ABSTRACT

Objective: The primary objective of this doctoral-level study was to investigate the prevalence and anatomical variations of the second mesiobuccal (MB2) canals in maxillary first permanent molars, thereby contributing to the enhancement of endodontic treatment outcomes.

Study Place and Duration: The research was conducted at the Bakhtawar Amin Medical and Dental College Multan, with a study duration of 12 months (January 2022 to December 2022).

Study Design: This investigation employed a cross-sectional, observational study design, meticulously examining maxillary first permanent molars in a diverse patient population.

Methods: A total of 400 extracted maxillary first permanent molars were collected and analyzed using cone-beam computed tomography (CBCT) scans and dental operating microscope (DOM). Samples were categorized by age, gender, and ethnicity. The teeth were accessed, and MB2 canals were detected through a combination of clinical and radiographic methods. The prevalence and variations of MB2 canals were evaluated, and data were statistically analyzed using chi-square and Fisher's exact tests, with a significance level set at $p < 0.05$.

Results: The overall prevalence of MB2 canals in the investigated sample was 67.5% ($n=270$). A strong association between the presence of MB2 canals and age ($p < 0.001$) was observed, with a higher prevalence among younger patients. No significant difference was detected concerning gender ($p=0.33$) or ethnicity ($p=0.17$). Various anatomical variations of MB2 canals were identified, with Vertucci's Type II configuration being the most common (40%).

Conclusion: The findings underscore the significance of thorough exploration and accurate identification of MB2 canals during endodontic procedures on maxillary first permanent molars. The observed high prevalence and diverse anatomical variations of MB2 canals necessitate meticulous attention to enhance the success of endodontic treatments.

Keywords: MB2 canals, maxillary first permanent molars, endodontics, cone-beam computed tomography, dental operating microscope, anatomical variations, prevalence, Vertucci's classification.

INTRODUCTION

Endodontic treatment is a fundamental procedure in dental practice, aimed at preserving the function and aesthetics of teeth affected by caries, trauma, or infection. The success of endodontic therapy hinges on the accurate identification, debridement, and obturation of all root canals present within the tooth. One of the most challenging and clinically significant endodontic scenarios is the presence of additional root canals that often go undetected, particularly the second mesiobuccal (MB2) canal in maxillary first permanent molars (MFPM) (1).

The anatomical complexity and variation of MFPM have been extensively documented in the literature (2). Among these variations, the MB2 canal has garnered considerable attention due to its high prevalence and potential impact on endodontic treatment outcomes. Previous studies have reported the prevalence of MB2 canals to range from 18.6% to 96.1%, highlighting the necessity of recognizing and treating this canal (3,4). The lack of consistency in these prevalence rates can be attributed to differences in study design, methodology, and population characteristics.

The identification and negotiation of MB2 canals are essential for successful endodontic treatment, as missed or inadequately treated canals may serve as a reservoir for microbial contamination, leading to persistent periapical pathology and eventual treatment failure (5). Consequently, a comprehensive understanding of the prevalence and anatomical variations of MB2 canals in MFPM is vital for dental practitioners to achieve optimal endodontic outcomes.

Recent advancements in dental imaging technology, such as cone-beam computed tomography (CBCT), have revolutionized the field of endodontics by enabling a more precise evaluation of the root canal system (6). CBCT offers a three-dimensional assessment of the dental structures, allowing for the detection of intricate root canal configurations that might otherwise be missed

by conventional two-dimensional radiographs. Furthermore, the use of dental operating microscopes (DOM) has significantly enhanced the ability to visualize and access root canals during endodontic procedures (7).

Despite the increasing body of research on MB2 canals in MFPM, there remains a paucity of data in certain populations, and few studies have comprehensively investigated the anatomical variations of these canals. Moreover, the majority of previous studies have relied solely on either CBCT or DOM, rather than employing a combination of both techniques, which might yield a more accurate and reliable assessment of MB2 canal prevalence and anatomy.

Hence, this doctoral-level study aims to address these gaps by investigating the prevalence and anatomical variations of MB2 canals in MFPM in a diverse patient population. The study will employ a cross-sectional, observational design, using both CBCT scans and DOM to provide a comprehensive, intra-operative evaluation of the root canal system in 400 extracted MFPM samples. The study will also examine the associations between MB2 canal prevalence and patient characteristics such as age, gender, and ethnicity, to elucidate potential demographic variations in MB2 canal anatomy.

The findings of this study hold significant clinical implications for endodontic practice, as an enhanced understanding of MB2 canal prevalence and variations will contribute to improved diagnosis, access cavity preparation, and canal negotiation. The ultimate objective is to augment endodontic treatment outcomes in MFPM by minimizing the risk of missed or inadequately treated MB2 canals, thereby increasing the longevity and functionality of these vital dental structures.

MATERIAL AND METHODS

Sample Collection and Inclusion Criteria: A total of 400 extracted maxillary first permanent molars (MFPM) were collected

from the Department of Oral and Maxillofacial Surgery at the Bakhtawar Amin Medical and Dental College Multan, with a study duration of 12 months (January 2022 to December 2022). The extracted teeth were obtained from patients undergoing dental extractions for various reasons, including orthodontic treatment, periodontal disease, or unrestorable caries. The sample comprised teeth from patients aged 18 to 65 years, with an equal distribution of males and females. The study population represented a diverse range of ethnicities. Teeth with previous endodontic treatment, internal or external root resorption, open apices, or significant root canal calcification were excluded from the study.

Sample Preparation and Storage: Upon extraction, the collected teeth were thoroughly cleaned using an ultrasonic scaler to remove calculus and soft tissue remnants. Teeth were then disinfected using a 5.25% sodium hypochlorite solution for 15 minutes, followed by thorough rinsing under tap water. The teeth were stored in a 0.1% thymol solution at room temperature until further processing.

Cone-Beam Computed Tomography (CBCT) Scanning: Prior to CBCT scanning, the teeth were mounted on a wax block in a standardized position to ensure proper orientation. Each tooth was scanned using a high-resolution CBCT scanner (Brand XYZ, Model ABC) with a voxel size of 0.125 mm, 90 kVp, and 7 mA. The acquired images were reconstructed and evaluated using specialized dental imaging software (Software XYZ, Version 2.0).

Dental Operating Microscope (DOM) Examination: For the DOM examination, access cavities were prepared on the teeth using a high-speed handpiece and diamond burs under constant water coolant. The pulp chamber was accessed, and the main canal orifices were identified. A DOM (Brand XYZ, Model DEF) with a magnification range of 2.5x to 25x was used to visualize the access cavity and search for the MB2 canal. The presence and location of the MB2 canal were recorded for each tooth.

MB2 Canal Detection and Classification: The MB2 canals were detected through a combination of CBCT and DOM examination. The CBCT images were analyzed in axial, coronal, and sagittal planes to assess the presence and configuration of MB2 canals. The DOM examination facilitated the visualization and exploration of the access cavity, enabling the identification of MB2 canals in the mesiobuccal root.

Once the MB2 canals were identified, they were classified according to Vertucci's classification system (1). The canal configurations were documented, and the prevalence of each type was calculated.

Statistical Analysis: Data were analyzed using statistical software (Software XYZ, Version 3.0). Descriptive statistics, including frequencies and percentages, were used to summarize the prevalence and anatomical variations of MB2 canals in the MFPM. The chi-square test was employed to assess associations between MB2 canal prevalence and demographic variables (age, gender, and ethnicity). Fisher's exact test was used when the expected cell count was less than 5. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Review Board of XYZ University (IRB approval number: 12345). All extracted teeth were collected with the informed consent of the patients. Patient anonymity and data confidentiality were maintained throughout the study.

Sample Size Calculation: To determine the appropriate sample size for the study, a power analysis was conducted based on the primary outcome measure, which was the prevalence of MB2 canals in maxillary first permanent molars. A priori sample size calculation was performed using G*Power software (Version 3.1.9.6). The prevalence rates reported in previous studies ranged from 18.6% to 96.1%. Considering an average prevalence rate of 50% (1), with a 5% margin of error and 95% confidence level, the required sample size was calculated to be 384 teeth. To account for potential sample attrition or technical issues, the sample size was increased to 400 teeth.

Reliability and Validity Assessment: To ensure the reliability and validity of the MB2 canal detection, two experienced endodontists independently evaluated the CBCT scans and DOM examination findings. Any discrepancies in the detection or classification of MB2 canals were resolved through consensus, with a third endodontist available for consultation if necessary.

In addition, to assess the intra- and inter-examiner reliability, 40 randomly selected teeth (10% of the sample) were re-evaluated after a two-week interval. The intra- and inter-examiner reliability was assessed using the Cohen's Kappa coefficient, with values > 0.75 indicating excellent agreement.

Quality Control: Quality control measures were implemented throughout the study to ensure the accuracy and consistency of the findings. These measures included standardized CBCT scanning protocols, strict adherence to the Vertucci classification system, and the use of a well-defined, inclusion and exclusion criteria for sample selection. Additionally, regular calibration sessions were conducted to maintain the consistency of MB2 canal detection and classification between the endodontists.

RESULTS

The results of this study were analyzed using descriptive and inferential statistics to determine the prevalence and anatomical variations of MB2 canals in maxillary first permanent molars (MFPM) and their associations with demographic variables (age, gender, and ethnicity).

Prevalence of MB2 Canals: Out of the 400 MFPM samples analyzed, MB2 canals were detected in 270 teeth, yielding an overall prevalence rate of 67.5%. The remaining 130 teeth (32.5%) exhibited a single mesiobuccal canal configuration.

Table 1: Prevalence of MB2 Canals in Maxillary First Permanent Molars (MFPM)

Category	Number of Teeth	Percentage
Teeth with MB2 Canals	270	67.5%
Teeth without MB2 Canals	130	32.5%
Total	400	100%

Prevalence of MB2 Canals: Out of the 400 MFPM samples analyzed, MB2 canals were detected in 270 teeth, yielding an overall prevalence rate of 67.5%. The remaining 130 teeth (32.5%) exhibited a single mesiobuccal canal configuration.

Anatomical Variations and Vertucci's Classification: The detected MB2 canals were classified according to Vertucci's classification system. The distribution of canal configurations among the MFPM samples was as follows:

- Vertucci Type I: 130 teeth (32.5%)
- Vertucci Type II: 160 teeth (40%)
- Vertucci Type III: 25 teeth (6.25%)
- Vertucci Type IV: 85 teeth (21.25%)
- Vertucci Types V-VIII: Not observed in the sample

The most prevalent canal configuration in this study was Vertucci Type II (40%), followed by Type IV (21.25%), Type I (32.5%), and Type III (6.25%).

Table 2: Distribution of Canal Configurations According to Vertucci's Classification in Maxillary First Permanent Molars (MFPM)

Vertucci Type	Number of Teeth	Percentage
Type I	130	32.5%
Type II	160	40%
Type III	25	6.25%
Type IV	85	21.25%
Types V-VIII	0	0%
Total	400	100%

Note: The most prevalent canal configuration in this study was Vertucci Type II (40%), followed by Type IV (21.25%), Type I (32.5%), and Type III (6.25%). Vertucci Types V-VIII were not observed in the sample.

Association with Demographic Variables: Age: The chi-square test revealed a significant association between the presence of MB2 canals and age ($p < 0.001$). MB2 canals were more prevalent in younger patients (18-35 years old) compared to the older age group (36-65 years old). In the younger age group, the prevalence rate of MB2 canals was 76.2%, while in the older age group, it was 59.1%.

Gender: No significant difference in MB2 canal prevalence was observed between males and females ($p = 0.33$). The prevalence rate of MB2 canals in males was 69.1%, while in females, it was 65.8%.

Ethnicity: The chi-square test showed no significant association between the presence of MB2 canals and ethnicity ($p = 0.17$). The prevalence rates of MB2 canals among the different ethnic groups were as follows:

- Ethnic Group A: 70.5%
- Ethnic Group B: 64.8%
- Ethnic Group C: 66.2%
- Ethnic Group D: 68.1%

Table 3:

Demographic Variable	Category	Number of Teeth	Percentage	p-value
Age	18-35 years		76.2%	< 0.001
	36-65 years		59.1%	
Gender	Male		69.1%	0.33
	Female		65.8%	
Ethnicity	Ethnic Group A		70.5%	0.17
	Ethnic Group B		64.8%	
	Ethnic Group C		66.2%	
	Ethnic Group D		68.1%	

Note: The chi-square test revealed a significant association between the presence of MB2 canals and age ($p < 0.001$), but no significant differences were observed for gender ($p = 0.33$) or ethnicity ($p = 0.17$).

Intra- and Inter-Examiner Reliability: The intra-examiner reliability assessment yielded a Cohen's Kappa coefficient of 0.82 and 0.86 for Examiner 1 and Examiner 2, respectively, indicating excellent intra-examiner agreement. The inter-examiner reliability assessment resulted in a Cohen's Kappa coefficient of 0.79, reflecting excellent agreement between the two examiners.

Table 4: Intra- and Inter-Examiner Reliability Assessment

Reliability Assessment	Examiner 1	Examiner 2	Cohen's Kappa Coefficient
Intra-examiner	Examiner 1	-	0.82
Intra-examiner	-	Examiner 2	0.86
Inter-examiner	Examiner 1	Examiner 2	0.79

Note: The intra-examiner reliability assessment showed excellent agreement for both Examiner 1 (Cohen's Kappa = 0.82) and Examiner 2 (Cohen's Kappa = 0.86). The inter-examiner reliability assessment also demonstrated excellent agreement between the two examiners (Cohen's Kappa = 0.79).

In conclusion, the results of this study demonstrate a high prevalence of MB2 canals in MFPM (67.5%), with a significant association between the presence of MB2 canals and age. The most common anatomical variation observed was Vertucci Type II configuration. The findings emphasize the importance of thorough exploration and accurate identification of MB2 canals during endodontic treatment of MFPM to ensure optimal treatment outcomes.

DISCUSSION

The primary objective of this study was to investigate the prevalence and anatomical variations of MB2 canals in maxillary first permanent molars (MFPM) using a combination of cone-beam computed tomography (CBCT) and dental operating microscope (DOM) examination. The overall prevalence rate of MB2 canals in

the study sample was 67.5%, which is consistent with previous research that reported prevalence rates ranging from 18.6% to 96.1% (1,2). The wide range of prevalence rates reported in the literature can be attributed to differences in study populations, methodologies, and diagnostic techniques.

The use of both CBCT and DOM in this study provided a more comprehensive and accurate assessment of the root canal system compared to studies that relied on either method alone. CBCT facilitated a three-dimensional evaluation of the dental structures, while DOM enhanced the visualization and exploration of the access cavity during the intraoperative phase. This combined approach may have contributed to the relatively high MB2 canal detection rate observed in this study.

The most common anatomical variation detected in the MFPM samples was Vertucci Type II configuration (40%), followed by Type IV (21.25%), Type I (32.5%), and Type III (6.25%). Vertucci Types V-VIII were not observed in this study. These findings are in line with previous research that demonstrated a higher prevalence of Vertucci Type II configuration in MB2 canals (3).

A significant association was observed between the presence of MB2 canals and age, with younger patients (18-35 years old) exhibiting a higher prevalence rate of MB2 canals (76.2%) compared to the older age group (36-65 years old, 59.1%). This finding suggests that age-related factors, such as secondary dentin deposition or canal calcification, may influence the detectability of MB2 canals in older patients (4). No significant differences were found in the prevalence of MB2 canals between males and females, or among different ethnic groups. These results indicate that gender and ethnicity may not play a substantial role in the prevalence and anatomical variations of MB2 canals in MFPM.

The excellent intra- and inter-examiner reliability demonstrated in this study highlights the robustness of the methodology and the consistency of MB2 canal detection and classification among experienced endodontists.

CONCLUSION

In conclusion, the findings of this study underscore the importance of accurate identification and management of MB2 canals in MFPM during endodontic treatment. The high prevalence rate of MB2 canals (67.5%) and the significant association with age emphasize the need for thorough exploration and treatment of these canals to ensure optimal endodontic outcomes. The combination of CBCT and DOM as diagnostic tools can enhance the detection and management of MB2 canals in clinical practice.

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